INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 15.4.2013 FN/AN; Time: 3 Hours, Full Marks: 50, Department: E & ECE
Number of Students 223 End Spring Semester Examination 2012-13
Subject No. EC 21008 Subject name: **Analog Electronic Circuits**
2nd year B. Tech.

Instruction: Answer ***ALL*** the questions in the same order as they appear in the question paper.
Answers to various parts of a question must be **together**.
Wherever necessary, you may make assumption(s) with reasonable justification.

Given: Saturation region drain current of an enhancement mode MOS transistor is

$$|I_{DS}| = K\left(|V_{GS}| - |V_{Th}|\right)^2\left(1 + \lambda|V_{DS}|\right)$$

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1. (a) For the amplifier circuit shown in Fig. Q1(a), it is given that $V_{TN} = |V_{TP}| = 2.0$ V, $K_n = K_p = 1$ mA/V^2, $\lambda_n = \lambda_p = 0.02$ V^{-1}. (i) Find the DC voltage at the gate of M1. (ii) Find the quiescent current through M1 and M2. (iii) Draw the small signal equivalent circuit of the amplifier for the mid-frequency range. (iv) Derive the expression and find out the numerical value of the small signal voltage gain of the amplifier. (v) Neatly sketch the output waveform v_{out} for $v_{in} = 1 + 0.01sin(2000\pi t)$ volt. (5)

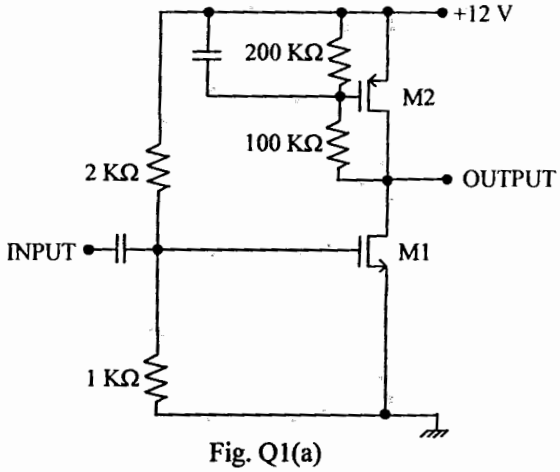

Fig. Q1(a)

(b) Assuming that all the transistors are identical in the circuit shown in Fig. Q1(b). Given that $|V_{TP}| = 1.5$ V, $K_p = 3$ mA/V^2 and $\lambda_p = 0$, find the range of the values of R (*i.e.* R_{min} and R_{max}), for which the current through the resistor R remains constant. What is the value of that constant current? (2+3)

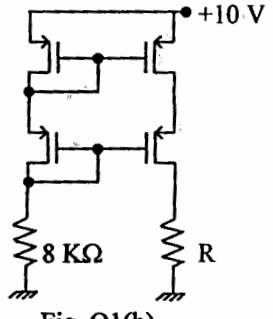

Fig. Q1(b)

2. (a) A fully differential amplifier with differential gain of 40 dB and common mode gain of 6 dB is stimulated with two signals $v_{in1} = sin(2000\pi t) + 0.01cos(8000\pi t)$ volt and $v_{in2} = sin(2000\pi t) + 0.05cos(8000\pi t)$ volt. Find the expressions for the output voltages v_{out1} and v_{out2}. (5)

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(b) Two identical *n*-channel MOS transistors and three identical *p*-channel MOS transistors are utilized to make a differential amplifier as shown in Fig Q2(b). Observed DC voltages at various points are provided in the figure. Find out the values of λ_n and λ_p for the MOS transistors. Calculate the differential gain, the common mode gain and the common mode rejection ratio of the differential amplifier. Assume that the common mode voltage at the input is zero. Given that $K_n = K_p = 1$ mA/V^2, $V_{TN} = 1.0$ V, $|V_{TP}| = 1.5$ V. (5)

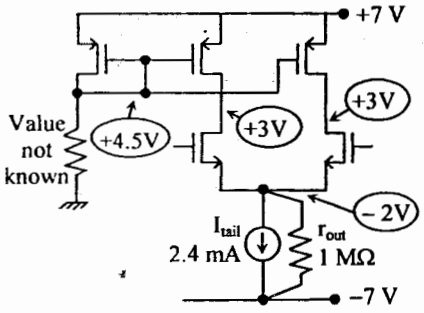

Fig. Q2(b)

3. (a) In Fig. Q3(a), **'A'** represents amplifier having a voltage gain of 300, an input resistance of 100 Ω and an output resistance of 5 KΩ; **'B'** represents ideal feedback network with a feedback factor of 0.03. Calculate the output voltage of the compound feedback amplifier when the input is driven by a signal source having a source resistance of 500 Ω and an open circuit signal voltage of 10 mV$_{pp}$. (5)

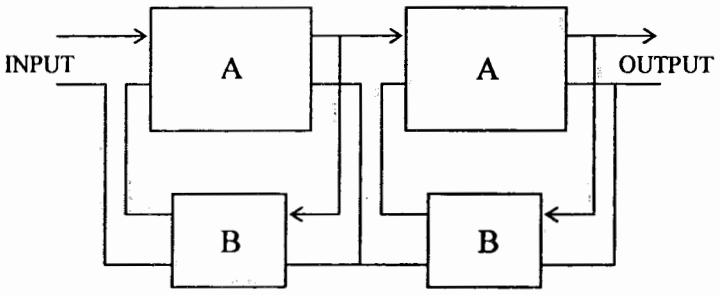

Fig. Q3(a)

(b) For the amplifier circuit shown in Fig. Q3 (b), find the voltage gain, input resistance and output resistance when (i) switch S is open and (ii) switch S is closed. Assume $V_{BE(on)} = 0.6$ V and $\beta_1 = \beta_2 = 100$. (5)

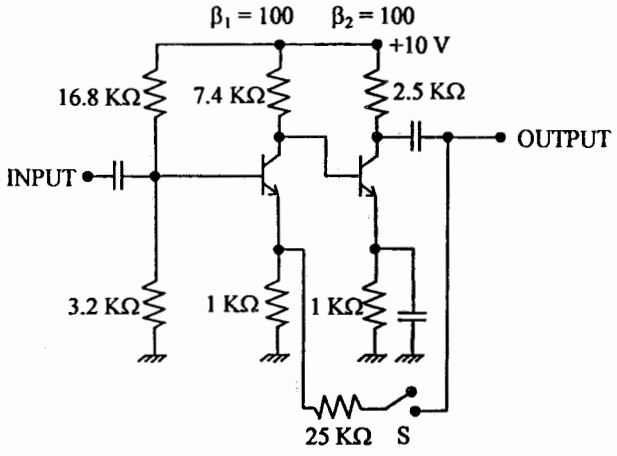

Fig. Q3(b)

4. (a) Name an L-C oscillator and draw the circuit diagram of the same. Mention the expressions for the frequency of oscillation and the minimum required voltage gain of the associated amplifier in terms of various component values. (3+2)

(b) Transfer function of the differential amplifier shown in Fig. Q4(b) is $\frac{A_0}{(1+\frac{s}{1000})}$. Assume that the amplifier has very high input resistance and very low output resistance. Construct a sinusoidal oscillator using the given circuit. Find the frequency of oscillation and the minimum value of A_0 required for sustaining oscillation.

(1+2+2)

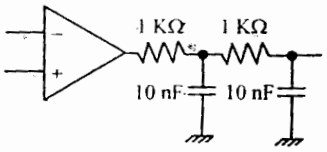

Fig. Q4(b)

5. (a) Define gain margin and phase margin. Draw the magnitude plot and phase plot of a multiple-pole system and clearly mark the gain margin and phase margin in the diagram. Also draw the Nyquist diagram for a stable system and indicate gain margin and phase margin therein. (2+2+1)

(b) Draw a Class A type power amplifier circuit using ±10 V power supply and a current source/sink of 5 mA. If a load resistor of 1 KΩ is connected between the output and the ground, then what will be the maximum power efficiency that can be obtained from the amplifier without distorting the output signal? What is/are the condition(s) to get the maximum power efficiency of the amplifier? (5)

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